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PATTERN OF POST-FIRE REGENERATION OF WHITE-BARK IN THE GREATER YELLOWSTONE AREA

1995

FINAL REPORT FOR RESEARCH AGREEMENT
#INT-90493-RJVA
"Patterns of Post-Fire Regeneration of White-Bark Pine in the Greater Yellowstone Area"
UNIVERSITY OF COLORADO AT DENVER
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FINAL REPORT FOR COOPERATIVE AGREEMENT

USDA INT-90493-RJVA

BETWEEN U.S. FOREST SERVICE INTERMOUNTAIN RESEARCH STATION FIRE SCIENCES LABORATORY

AND THE UNIVERSITY OF COLORADO AT DENVER:

PATTERNS OF POST-FIRE REGENERATION OF WHITEBARK PINE IN THE GREATER YELLOWSTONE AREA

From

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INTRODUCTION

In the mid-1980s, growing recognition of severe declines in whitebark pine (Pinus albicaulis) ecosystems by the Intermountain Research Station lead to active support of research elucidating important aspects of ecology and biology of the species, particularly those relating to fire. One such aspect is the patterns and processes associated with post-fire regeneration. Whitebark pine, in contrast to its wind-dispersed conifer associates, depends on seed dispersal by a bird, Clark's Nutcracker (Nucifraga columbiana). Nutcrackers disseminate whitebark pine by burying subterranean caches of 1 to 15 or more seeds each throughout the forest landscape. These caches are retrieved by nutcrackers as a food supply during winter and spring months. In good cone crop years, more caches may be buried by birds than are required, and these may germinate in the next summer, following snowmelt or summer rains. Post-fire regeneration of whitebark pine, thus, depends on nutcrackers using burned areas for burying their seed stores. Potentially, the post-fire patterns of regeneration for whitebark pine could differ from that of typical wind-dispersed conifers. The 1988 Yellowstone fires provided an important opportunity to study the dynamics of early post-fire whitebark pine.

Whitebark pine occurs both on the higher plateaus within Yellowstone National Park, including the Mt. Washburn massif, and on the mountain ranges around the park. According to Dr. Henry Shovic, about 15% of the area occupied by the ABLA-PIAL/VASC habitat type burned during the 1988 fires. This habitat type

constitutes the major occurrence of seral whitebark pine communities.

DURATION OF THE COOPERATIVE AGREEMENT

Because the 1988 fires were followed in 1989 by an abundant whitebark pine cone crop in the Greater Yellowstone Area, the first whitebark pine regeneration was expected in 1990. Thus, this cooperative agreement began in 1990 and initially included the 1990, 1991, and 1992 field seasons. Virtually no whitebark pine regeneration occurred until the summer of 1991. As a result, the data were inadequate for determining trends. Consequently, the cooperative agreement was extended to include the 1994 field season for the purpose of gathering additional data (and reconstructing the 1993 regeneration). A new cooperative agreement has just been arranged ("Seven year post-fire regeneration patterns of whitebark pine in the Greater Yellowstone Area"), so that one additional field season of data may be obtained to confirm trends to date.

THE SCOPE OF THIS REPORT

In this report I outline the major results of this study that correspond to the primary objectives of the original cooperative agreement. I present data in the form of figures for quick and easy reference. Since I will be gathering one more field season of data, I declined to draft at this time a publication-quality manuscript that would serve also as a final report. Instead, one or more publication-quality manuscripts will be drafted before June

30, 1996, as a final report for the new cooperative agreement. These manuscripts will present detailed data based on the entire study period, 1990 through 1995.

At this time all data collected from 1990 through 1994 are on a database (Yellowstone, PCfile 5.01). The data have been imported to Statgraphics Plus, a high-powered, Windows-based, statistical package; we have generated descriptive statistics, ANOVAs, and t-tests, comparing study areas, treatments, etc., for each year of the study (except 1993). A floppy disc containing the database is available upon request.

ORIGINAL STUDY OBJECTIVES

This study originated from RFP-22-90-001, Problem No. 2: "Patterns of post-fire regeneration of whitebark pine in the Greater Yellowstone Area," Greater Yellowstone Area Research, Intermountain Research Station, Ogden, Utah. The following objectives were from the original RFP:

1. Set up permanent plots for the collection of data on patterns of postfire whitebark pine regeneration for 3 or more years of study.

2. Determine the density of whitebark pine regeneration over 3 field seasons with respect to a) differences in burn severity and b) differences in ecological site types.

Long term goals identified for objective 2 included measuring

regeneration density with respect to year-to-year variation in precipitation and cone crop size.

3. Determine the density of whitebark pine regeneration in comparable non-burned sites in 1990 and again in 1992 or later. Treatments are based only on differences in ecological site types.

4. Measure whitebark pine seedling survival over 3 field seasons with respect to a) initial seedling density, b) differences in burn severity, and c) differences in ecological site types.
A long term goal for objective 4 was the measurement of seedling survival with respect to year-to-year variation in precipitation.

The only modification of the original study plan occurred with respect to burn severity. In the two selected study areas, Cooke City and Mt. Washburn, nearly all potential treatments sites experienced stand-replacing fire. Only in the Mt. Washburn vicinity did we find one moist site that primarily experienced surface and ground fire. In addition, we gathered data on regeneration in the non-burned control sites in all field seasons and not just in 1990 and 1992, as originally proposed in objective 3.

I believe that **all objectives of the study have been met,** including the long-term objectives under objective 2. Through Phil Perkins in Yellowstone National Park, I obtained data on wet and frozen precipitation from the Tower Ranger for the years 1990 through 1994. These data have enabled me to examine the

relationship between regeneration and precipitation.

A REVIEW OF STUDY AREAS AND METHODS

I selected the Yellowstone National Park study areas and treatment sites in the field in 1990 with representatives of the Park and the Intermountain Research Station: Steve Arno, Don Despain, and Ward McCaughey. Dick Kracht, Ward McCaughey, and Steve Arno helped select the sites in the Gallatin National Forest, outside of Cooke City.

In 1990 my students and I established a total of 275 permanent, circular plots, each 20 square meters in area, at subalpine elevations in the Greater Yellowstone Area. Each plot was marked in the center by a rebar stake bearing a numbered, metal tag. When we work within a plot, we temporarily mark the perimeter with surveying flags. In order to do this, we use a radius line on a loop; the loop is placed over the rebar stake. The line is 2.523 m in length to achieve a circular area of 20 square meters.

The Cooke City study area occurs northeast of the town of Cooke City in the Fisher Creek drainage, Beartooth Mountains, Gallatin National Forest, a few kilometers from the northeast entrance to Yellowstone National Park. Part of this study area was backburned to save Cooke City from the Storm Creek Fire in 1988. The Mt. Washburn study area occurs in the northcentral region of Yellowstone National Park; in 1988 much of the subalpine forest on and around Mt. Washburn was burned by the North Fork Fire.

In the Cooke City study area we selected four sites for plots

representing the following treatments: dry, severely burned (50 plots); moist, severely burned (50 plots); dry, unburned (25 plots); and moist, unburned (25 plots). Plot aspects ranged from 80° to 180°, and elevation ranged from 2680 to 2745 m. On Mt. Washburn we selected three sites for plots, representing the following treatments: dry, severely burned (50 plots); moist, severely burned (50 plots); moist, moderately burned (25 plots). Aspects ranged from 250° to 360°, and elevation ranged from 2560 to 2745 m.

In 1990, 1991, 1992, and 1994, with a team of students, we thoroughly searched each plot, burned and unburned for germinants and older regeneration for each conifer species. Each year, we began fieldwork about July 12 and ended about August 10. Each plot was carefully examined by a minimum of two different people. New seedlings and older seedlings were counted for all conifer seedlings; heights were measured for all seedlings not new germinants and ages estimated. Single whitebark pine seedlings or a cluster of seedlings (from one cache) were designated as a single regeneration site. Whitebark pine regeneration sites were mapped with respect to the center of the plot, with distance and compass heading from the rebar stake. I was able to follow individual whitebark pine seedlings from year to year and observe patterns of mortality and changes in cluster size. In 1990, with advice on methodology from Henry Shovic, we took char depth measurements for all plots in burned treatments.

MAJOR PATTERNS FROM 1990 TO 1994

Cone production. With respect to whitebark pine cone production during the study, in 1989 there was a major cone crop throughout the Greater Yellowstone Area, raising expectations for the first regeneration in summer, 1990. The next cone crop, a moderate one, occurred in 1991, and a small cone crop occurred in 1992. Essentially no cone production has occurred since this time. My field observations of cone production are confirmed by cone crop transect data from Republic Creek and Mt. Washburn (two stands) collected by the Interagency Grizzly Bear Study Team; I thank Bonnie Blanchard for making these data available to me.

Char depth. Mean char depth measurements per plot ranged from 0.3 cm for the Cooke City dry, severely burned treatment to 6.6 cm for the Mt. Washburn moist, moderately burned treatment. In general, char depths were lowest for the Cooke City burned treatments and highest for the Mt. Washburn moist treatments (Fig. 1).

Regeneration. In 1990, despite the heavy whitebark pine cone crop in 1989, no whitebark pine regeneration occurred on any of the burned treatments. From 1991 through 1994, the highest densities of whitebark pine regeneration occurred on the Mt. Washburn moist treatments and the lowest on the Cooke City unburned treatments (Fig. 2). The low regeneration densities on the unburned treatments are likely the result of both poor seedbed and relatively lower caching densities by nutcrackers. Thus, fire does increase whitebark pine regeneration, and moisture plays a key role

with respect to density of regeneration.

Germination. Patterns of occurrence of new germination each year are shown in Fig. 3. The regeneration originating in 1993 that survived to 1994 is displayed separately in Fig. 4, since total 1993 regeneration cannot be reconstructed. Overall, we see that the Cooke City moist, severely burned treatment experienced some regeneration in 4 different years, as did the Cooke City moist, unburned treatment and the Mt. Washburn moist, moderately burned treatment. Although the Mt. Washburn moist, severely burned treatment experienced new regeneration in only three different years, the densities of new regeneration in 1991 and 1993 were extremely high.

As noted in Figs. 3 and 4, some new whitebark pine regeneration occurred in every year on burned treatments, except 1990, despite poor cone crops the previous fall. I believe that much of this new regeneration is caused by delayed germination of seeds cached by nutcrackers in 1989, 1991, and 1992. In several instances we had clusters of seedlings one or more years of age with new germinants coming up in their midst.

Spring moisture. Moisture appears to be especially critical to germination of whitebark pine seeds. The highest densities of new regeneration and greatest numbers of years of new regeneration occurred on the moist treatment plots, as noted above. In addition, precipitation data from the Tower Ranger Station in Yellowstone National Park indicates a relationship between heavy, late spring snowfall and peak germination; 1991 and 1993 were peak

germination years, and in both these years there was high snowfall in April (Fig. 5 and 6). Given the high snowfall in April of 1995, this hypothesis can be tested in summer 1995.

Mortality patterns. The highest regeneration mortality, determined by following the 1991 cohort to 1992 (Fig. 7) and the 1990 to 1992 cohorts to 1994 (Fig. 8) occurred in the moist, burned treatments (mortality in the Cooke City unburned treatments is based on sample sizes too small to be meaningful). Thus, both regeneration density and mortality are greatest in these moist treatments.

That mortality would be highest in the moist treatments appears somewhat counterintuitive. I suggest an explanation: In moist years (high spring snowpack) seeds may be germinating on microsites that are unfavorable to seedling survival during drier years. We do not see as much germination on dry sites in moist years as we do on the moist sites, probably because the dry sites remain unfavorable even after some additional precipitation.

Importance of 1995 field season. With at least one additional field season, I can determine if the previous trends regarding regeneration density, new regeneration, and regeneration mortality with respect to ecological treatments hold. I can also test the hypothesis that April snowfall may predict high germination rates. Since the last cone crop was in 1992, this is also an opportunity to determine whether delayed germination will ensure continuity of regeneration.

Other conifers. I have gathered regeneration data on other

conifers as well. There has been some regeneration in every year of the study for the other three conifers, and survivorship has been unexpectedly high. The patterns for spruce, fir, and lodgepole pine appear much different than that for whitebark pine. For example, spruce rarely occurs on dry, burned treatments, and fir is lower in density than spruce on moist, burned treatments. Although moisture may play some role in germination and survivorship of these other conifers, the interaction appears different. for example, previous seed production coupled with summer rains may be of greater importance.

SUMMARY OF RESULTS TO DATE

1. The burned treatments support greater densities of whitebark pine regeneration (since 1990) than do the unburned treatments.

2. The moist, burned treatments in general support higher densities of whitebark pine regeneration than do the dry, burned treatments.

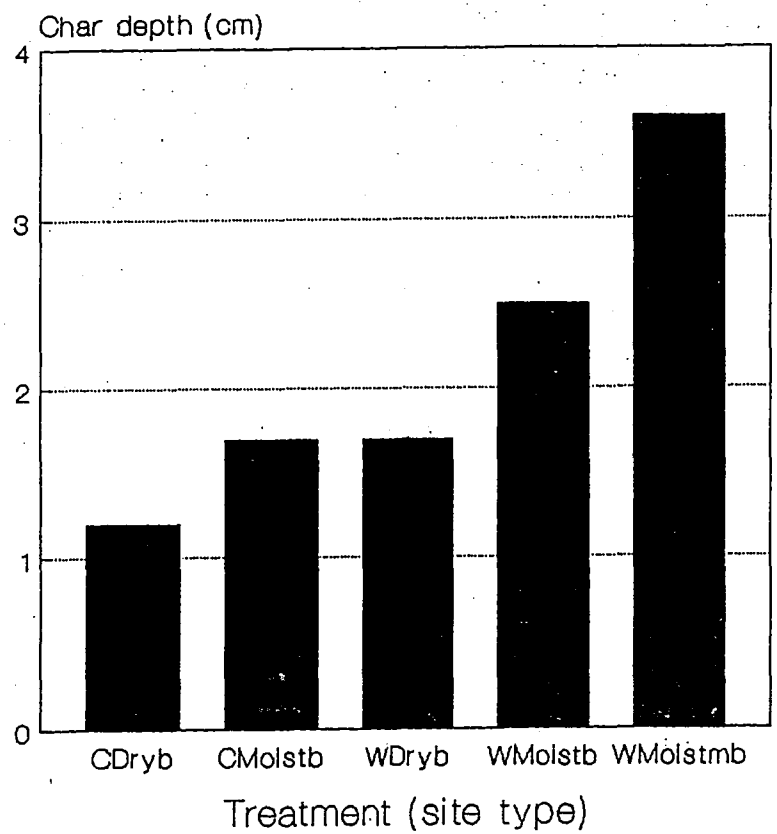
3. The highest regeneration densities of all occur in the Mt. Washburn study area on the moist, severely burned treatment and on the moist, moderately burned treatment.

4. The years of greatest whitebark pine germination were 1991 and 1993. These years corresponded to annual precipitation patterns that featured high April snowpack.

5. The years of highest whitebark pine germination, 1991 and 1993, did **not** follow the years of highest cone production (1989 and 1991). This finding plus the occurrence of some regeneration in every year except 1990 suggests that delayed germination is a common occurrence in whitebark pine and that germination is triggered by high moisture levels. Delayed germination results in continuity of germination over time.

6. Although regeneration was highest on moist-treatment plots, mortality was also highest on these plots.

Char Depths
Cooke(C) Washburn(W)



Measured in 1990

Fig. 1

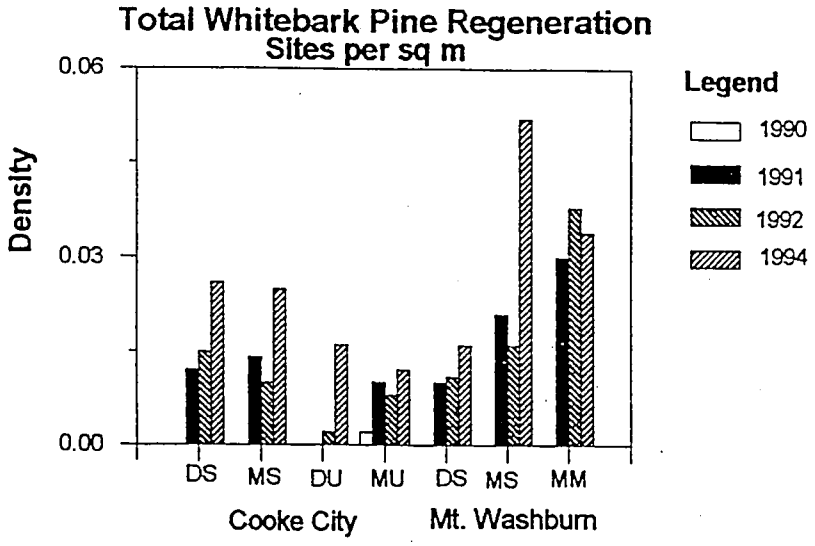


Fig. 2 Study area/treatment

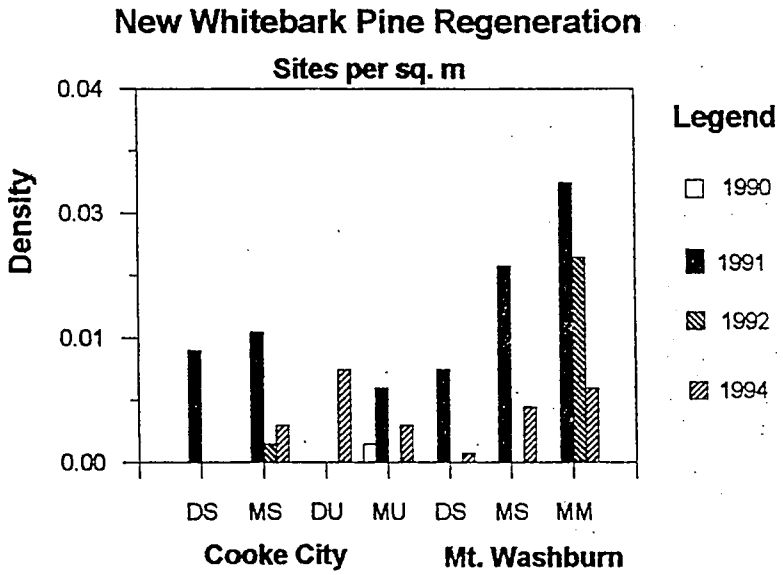


Fig. 3 Study area/treatment

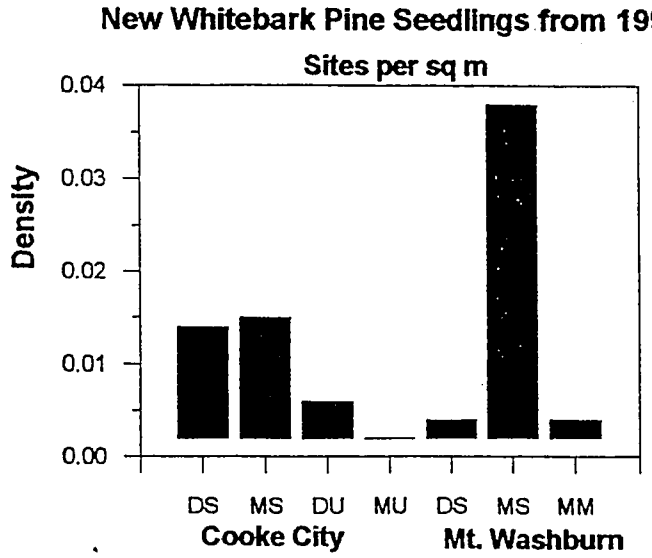
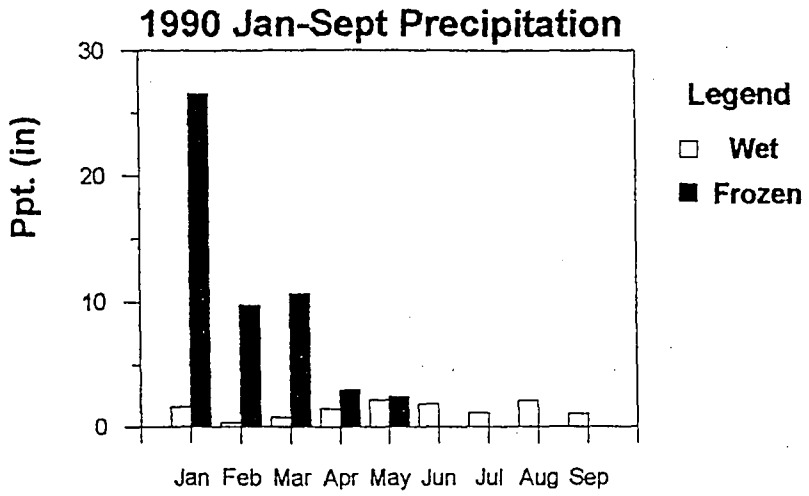
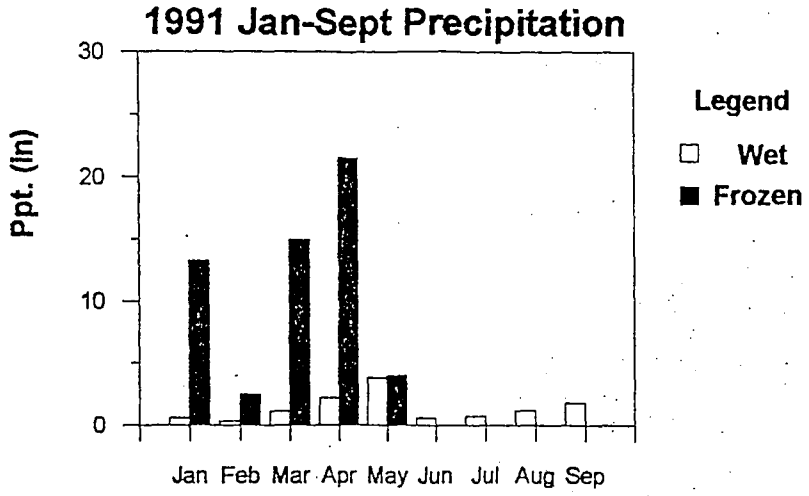


Fig. 4 Study area/treatment


1990 Jan-Sept Precipitation
Ppt. (in)
30
20
10
0
Jan Feb Mar Apr May Jun Jul Aug Sep
Legend
Wet
Frozen


1991 Jan-Sept Precipitation
Ppt. (In)
30
20
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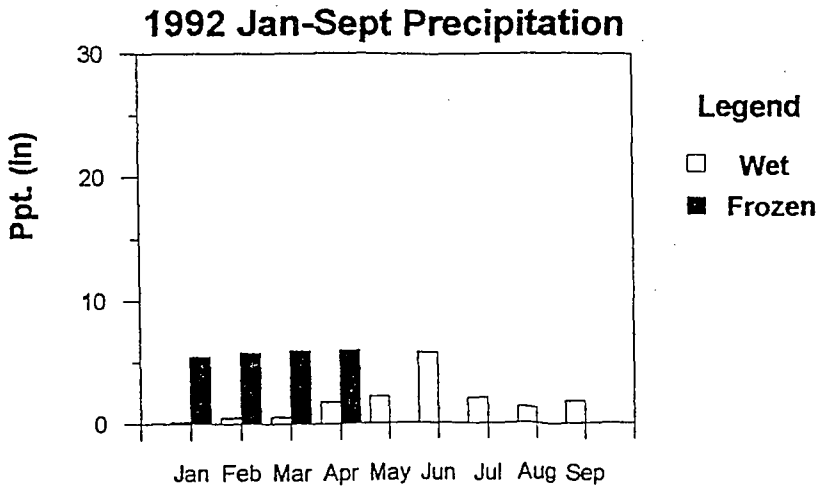
0
Jan Feb Mar Apr May Jun Jul Aug Sep
Legend
Wet
Frozen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Ppt. (In)
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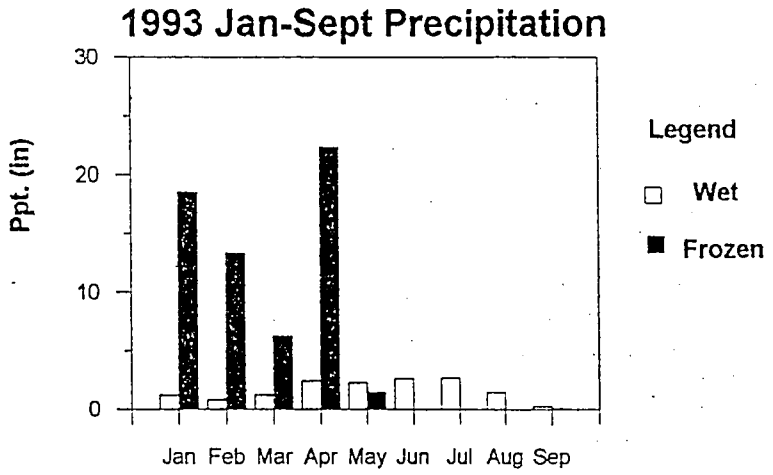
Jan Feb Mar Apr May Jun Jul Aug Sep
Legend
Wet
Frozen

Fig. 5


1993 Jan-Sept Precipitation
Ppt. (in)
30
20
10
0
Jan Feb Mar Apr May Jun Jul Aug Sep
Legend
Wet
Frozen

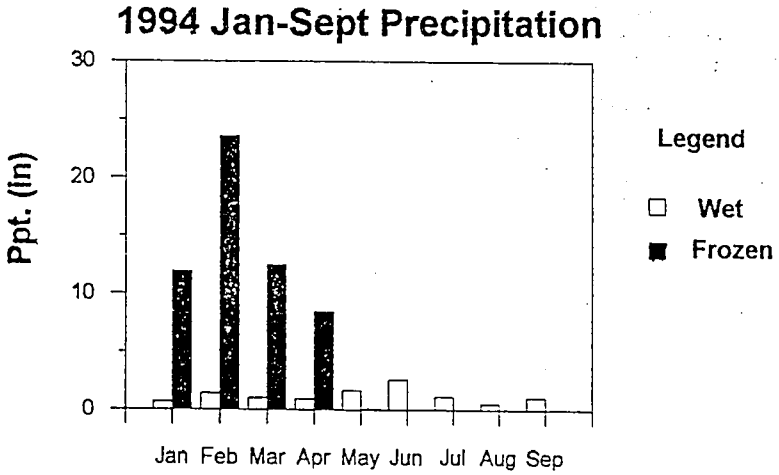

1994 Jan-Sept Precipitation
Ppt. (in)
30
20
10
0
Jan Feb Mar Apr May Jun Jul Aug Sep
Legend
Wet
Frozen

Fig. 6

Seedling Mortality
Percent Loss 1991 to 1992

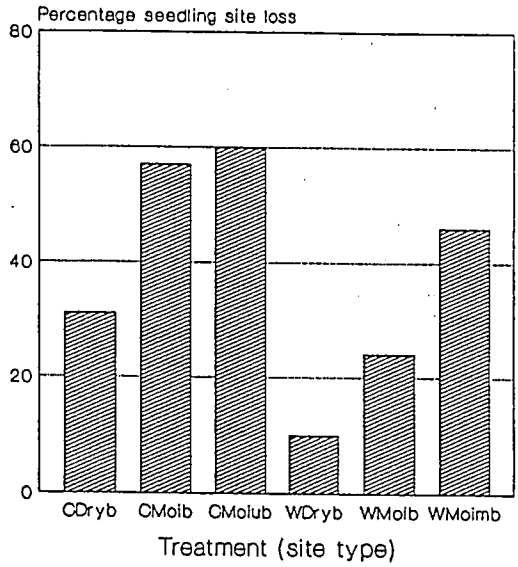


Fig. 7

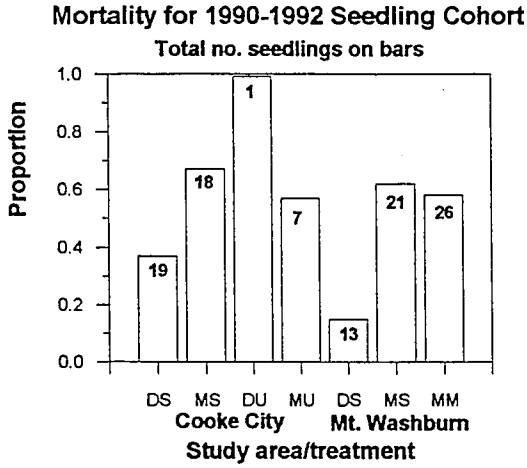


Fig. 8